

PROCESS FOR FABRICATING A LEADLESS PLASTIC CHIP CARRIER

CROSS REFERENCE TO RELATED APPLICATION

[0001] This is a continuation-in-part of U.S. patent application serial no. 09/802,678, filed March 9, 2001, which is a continuation-in-part of U.S. patent application serial no. 09/288,352, now U.S. patent no. 6,498,099, issued December 24, 2002, which is a continuation-in-part of U.S. patent application serial no. 09/095,803, now U.S. patent no. 6,299,200, issued May 8, 2001.

FIELD OF THE INVENTION

[0002] The present invention relates in general to integrated circuit packaging, and more particularly to an improved process for fabricating a leadless plastic chip carrier.

BACKGROUND OF THE INVENTION

[0003] According to well known prior art IC (integrated circuit) packaging methodologies, semiconductor dice are singulated and mounted using epoxy or other conventional means onto respective die attach pads (attach paddles) of a leadframe strip. Traditional QFP (Quad Flat Pack) packages incorporate inner leads which function as lands for wire bonding the semiconductor die bond pads. These inner leads typically require mold locking features to ensure proper positioning of the leadframe strip during subsequent molding to encapsulate the package. The inner leads terminate in outer leads that are bent down to contact a mother board, thereby limiting the packaging density of such prior art devices.

[0004] In order to overcome these and other disadvantages of the prior art, the Applicants previously developed a Leadless Plastic Chip Carrier (LPCC). According to Applicants' LPCC methodology, a leadframe strip is provided for supporting several hundred devices. Singulated IC dice are placed on the strip die attach pads using conventional die mount and epoxy techniques. After curing of the epoxy, the dice are wire bonded to the peripheral internal leads by gold (Au), copper (Cu), aluminum (Al) or doped aluminum wire bonding. The leadframe strip is then molded in plastic or resin using a modified mold wherein the bottom cavity is a flat plate. In the resulting molded package, the die pad and leadframe inner leads are exposed. By

exposing the bottom of the die attach pad, mold delamination at the bottom of the die paddle is eliminated, thereby increasing the moisture sensitivity performance. Also, thermal performance of the IC package is improved by providing a direct thermal path from the exposed die attach pad to the motherboard. By exposing the leadframe inner leads, the requirement for mold locking features is eliminated and no external lead standoff is necessary, thereby increasing device density and reducing package thickness over prior art methodologies. The exposed inner leadframe leads function as solder pads for motherboard assembly such that less gold wire bonding is required as compared to prior art methodologies, thereby improving electrical performance in terms of board level parasitics and enhancing package design flexibility over prior art packages (i.e. custom trim tools and form tools are not required). These and several other advantages of Applicants' own prior art LPCC process are discussed in Applicants' United States patent no. 6,299,200, the contents of which are incorporated herein by reference.

[0005] Applicants' LPCC production methodology utilizes saw singulation to isolate the perimeter I/O row as well as multi-row partial lead isolation. Specifically, the leadframe strip is mounted to a wafer saw ring using adhesive tape and saw-singulated using a conventional wafer saw. The singulation is guided by a pattern of fiducial marks on the bottom side of the leadframe strip. Also, special mold processing techniques are used to prevent the mold flow from bleeding onto the functional pad area and inhibiting electrical contact. Specifically, the exposed die pad surface is required to be deflashed after molding to remove any molding compound residue and thereby allow the exposed leads and die attach pad to serve as solder pads for attachment to the motherboard.

[0006] According to Applicants' U.S. patent no. 6,498,099, the contents of which are incorporated herein by reference, an etch back process is provided for the improved manufacture of the LPCC IC package. The leadframe strip is first subjected to a partial etch on one or both of the top and bottom surfaces in order to create a pattern of contact leads (pads) and a die attach pad (paddle). After wire bonding the contacts to a singulated semiconductor die, followed by overmolding and curing of the mold, the leadframe strip is exposed to a second full etch immersion for exposing the contact pads in an array pattern (i.e. multi-row) or perimeter pattern (i.e. single row), as well as the die attach pad. In the case of a package with multi-row I/O leads, this etch back step eliminates the requirement for two additional saw singulation operations (i.e. to sever the inner leads from the outer leads), and in both the single-row and multi-row configurations, the etch back step eliminates post mold processing steps (e.g. mold

deflashing) and ensures superior device yield over the processing technique set forth in Applicants' United States patent no. 6,299,200. Additionally, using this technique allows for higher I/O pad density and also allows for pad standoff from the package bottom which reduces stress in the solder joint during PCB temp cycling. Further, the technique allows for the use of a pre-singulation strip testing technique given that the electrical I/O pads are now isolated from each other and testing in strip can take place. This feature greatly increased the handling and throughput of the test operation.

[0007] In Applicant's co-pending U.S. application serial no. 09/802,678, Entitled Leadless Plastic Chip Carrier With Etch Back Pad Singulation, filed March 9, 2001, the contents of which are incorporated herein by reference, the etch-back LPCC process of Applicants' United States patent no. 6,498,099 is modified to provide additional design features. The leadframe strip is selectively covered with a thin layer photo-resist mask in predetermined areas. Following the application of the mask, an etch-barrier is deposited as the first layer of the contact pads and die attach pad, followed by several layers of metals which can include for example, Ni, Cu, Ni, Au, and Ag. This method of formation of the contact pads allows plating of the pads in a columnar shape and into a "mushroom cap" or rivet-shape as it flows over the photoresist mask. The shaped contact pads are thereby locked in the mold body, providing superior board mount reliability. Similarly, the die attach pad can be formed in an interlocking shape for improved alignment with the die. The photo-resist mask is then rinsed away and the semiconductor die is mounted to the die attach pad. This is followed by gold wire bonding between the semiconductor die and the peripheral contact pads and then molding as described in Applicant's United States patent no. 6,299,200. The leadframe is then subjected to full immersion in an alkaline etchant that exposes a lower surface of an array of the contact pads, a power ring and the die attach pad, followed by singulation of the individual unit from the full leadframe array strip.

[0008] These processes include the deposition or plating of either a thick layer of metal, or a plurality of layers of metal to form a robust three-dimensional construction of contact pads and the die attach pad. The deposition of successive layers of metal can be time consuming and relatively expensive and still further improvements in manufacturing are driven by industry demand.

[0009] It is desirable to provide an improved process for manufacturing a leadless plastic chip carrier using an etch-back step rather than a deposition stage or stages.

SUMMARY OF THE INVENTION

[0010] In one aspect of the present invention there is provided a process for fabricating a leadless plastic chip carrier. The process includes laminating a first copper strip to a second copper strip to form a leadframe strip, selectively etching the first copper strip to define at least a die attach pad and at least one row of contact pads, mounting a semiconductor die to the die attach pad and wire bonding the semiconductor die to ones of the contact pads, encapsulating a top surface of the leadframe strip in a molding material removing the second copper strip, thereby exposing the die attach pad and the at least one row of contact pads, and singulating the leadless plastic chip carrier from the leadframe strip

[0011] In another aspect of the present invention, there is provided a process for fabricating a leadless plastic chip carrier. The process includes providing a first copper strip, depositing solder on an upper surface and a lower surface of a second copper strip, hot roll solder reflow joining of the first copper strip to the second copper strip, with a solder flux disposed between the copper strips, to solder bond the first copper strip and the second copper strip, thereby forming a leadframe strip, selectively plating at least one of silver, nickel/gold, and nickel/palladium to an upper surface of the first copper strip, in a pattern of at least one row of contact pads, depositing an etch-resist mask on a top surface of the leadframe strip, the portion of the upper surface forming a die attach pad, etching the top surface of the leadframe strip to define at least the die attach pad and the at least one row of contact pads, stripping off the etch-resist mask, mounting a semiconductor die to the die attach pad and wire bonding the semiconductor die to ones of the contact pads, encapsulating the top surface of the leadframe strip in a molding material, stripping the solder on the lower surface of the second copper strip, etching away the second copper strip, reflowing to separate solder plating from a bottom surface of the molding material, and singulating the leadless plastic chip carrier from the leadframe strip.

[0012] In still another aspect of the present invention, there is provided a process for fabricating a leadless plastic chip carrier. The process includes selectively plating at least one of silver, nickel/gold, and nickel/palladium to an upper surface of a first copper strip, in a pattern of at least one row of contact pads, depositing solder on an upper surface and a lower surface of a second copper strip, hot roll solder reflow joining of the first copper strip to the second

copper strip, with a solder flux disposed between the copper strips, to solder bond the first copper strip and the second copper strip, thereby forming a leadframe strip, depositing an etch-resist mask on a top surface of the leadframe strip, the portion of the upper surface forming a die attach pad, etching the top surface of the leadframe strip to define at least the die attach pad and the at least one row of contact pads, stripping off the etch-resist mask, mounting a semiconductor die to the die attach pad and wire bonding the semiconductor die to ones of the contact pads, encapsulating the top surface of the leadframe strip in a molding material, stripping the solder on the lower surface of the second copper strip, etching away the second copper strip, reflowing to separate solder plating from a bottom surface of the molding material, and singulating the leadless plastic chip carrier from the leadframe.

[0013] In another aspect of the present invention, a process for fabricating a leadless plastic chip carrier is provided the process includes laminating a first metal strip to a second metal strip to form a leadframe strip, selectively etching said first metal strip to define at least a row of contact pads, mounting a semiconductor die to said second metal strip, on a same side thereof as said contact pads and wire bonding said semiconductor die to ones of said contact pads, encapsulating a top surface of said leadframe strip in a molding material, removing said second metal strip, thereby exposing said semiconductor die and said row of contact pads, and singulating the leadless plastic chip carrier from the leadframe strip.

[0014] In another aspect of the present invention, a process for fabricating a leadless plastic chip carrier is provided. The process includes providing a first metal strip, depositing one of tin and solder on an upper surface and a lower surface of a second metal strip, hot roll solder reflow joining of said first metal strip to said second metal strip, with a solder flux disposed between the metal strips, to solder bond said first metal strip and said second metal strip, thereby forming a leadframe strip, selectively plating at least one of silver, nickel/gold, and nickel/palladium to an upper surface of said first copper strip, in a pattern of at least one row of contact pads, etching said top surface of said leadframe strip to define said at least one row of contact pads, mounting a semiconductor die to said second metal strip and wire bonding said semiconductor die to ones of said contact pads, encapsulating said top surface of said leadframe strip in a molding material, stripping said one of tin and solder on said lower surface of said second metal strip, removing said second metal strip, reflowing to separate said one of tin and solder from a bottom surface of the molding material, and singulating the leadless plastic chip carrier from the leadframe strip.

[0015] In yet another aspect, a process for fabricating a leadless plastic chip carrier is provided. The process includes selectively plating at least one of silver, nickel/gold, and nickel/palladium to an upper surface of a first metal strip, in a pattern of at least one row of contact pads, depositing one of tin and solder on an upper surface and a lower surface of a second metal strip, hot roll solder reflow joining of said first metal strip to said second metal strip, with a solder flux disposed between the metal strips, to solder bond said first metal strip and said second metal strip, thereby forming a leadframe strip, etching said top surface of said leadframe strip to define said at least one row of contact pads, mounting a semiconductor die to said second metal strip and wire bonding said semiconductor die to ones of said contact pads, encapsulating said top surface of said leadframe strip in a molding material, stripping said one of tin and solder on said lower surface of said second metal strip, etching away said second metal strip, reflowing to separate said one of tin and solder from a bottom surface of the molding material, and singulating the leadless plastic chip carrier from the leadframe.

[0016] Advantageously, a robust three dimensional structure results from laminating a pair of strips of copper and selectively etching back the copper to leave the die attach pad, the power ring and the I/O contacts. The process therefore includes etching back rather than a deposition stage to form the contacts, the power ring and the die attach pad. Also, it is not necessary to use gold as an etch resist or as a bondable surface, thus resulting in material cost savings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The invention will be better understood with reference to the following drawings, in which:

[0018] Figures 1A to 1O show a process for manufacturing a leadless plastic chip carrier, according to a first embodiment of the invention;

[0019] Figures 2A to 2O show a process for manufacturing a leadless plastic chip carrier, according to a second embodiment of the invention;

[0020] Figure 3 shows a bottom view of the leadless plastic chip carrier of Figure 1O;

[0021] Figures 4A to 4M show a process for manufacturing a leadless plastic chip carrier, according to a third embodiment of the invention; and

[0022] Figures 5A to 5M show a process for manufacturing a leadless plastic chip carrier, according to fourth embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0023] Reference is made to Figures 1A to 1L which show the process for manufacturing a leadless plastic chip carrier (LPCC) according to a first embodiment of the present invention. Referring first to Figure 1A, an elevation view is provided of a first metal strip 18 that forms a part of the raw material of the leadframe strip (indicated generally by the numeral 20 in Figure 1G). In the present embodiment, the metal strip 18 is a copper strip. As discussed in greater detail in Applicant's own United States patent no. 6,299,200, issued May 8, 2001, the contents of which are incorporated herein by reference, the leadframe strip 20 is divided into a plurality of sections. Each of the sections incorporates a plurality of leadframe units in an array (e.g. 3 x 3 array, 5 x 5 array, etc.). Only one such unit is depicted in the elevation views of the Figures, portions of adjacent units being shown by stippled lines.

[0024] The metal strip 18 is selectively plated with a preplating metal using plating resist to define the plating areas. Preferably, the preplating metal is silver (Ag), nickel and gold (Ni/Au) or nickel and palladium (Ni/Pd) (Figure 1B). The preplating metal is selectively plated in a pattern of a ground ring pad 22, a power ring 24, and contact or I/O pads 26.

[0025] Referring to Figure 1C, an elevation view is provided of a second metal strip 28 that forms a second part of the raw material of the leadframe strip 20. In the present embodiment, the second metal strip 28 is a copper strip. The second metal strip 28 is similar to the first metal strip 18 and therefore need not be further described herein.

[0026] The second metal strip 28 is plated with tin (Sn) or solder on both upper and lower surfaces thereof (Figure 1D). The coating serves to enhance lamination and etching resist.

[0027] Next, a solder flux is applied to the top, tin-plated surface of the second metal strip 28 (Figure 1E). In an alternative embodiment, flux is applied to the bottom surface of the first metal strip 18.

[0028] The first and second metal strips 18, 28, respectively, are then laminated together by hot rolling with the solder flux disposed therebetween (Figures 1F and 1G). The hot rolling causes the plated tin or solder to reflow and wet the bottom surface of the first metal strip 18,

thereby solder bonding the first metal strip 18 to the second metal strip 28. After hot rolling, the leadframe strip 20 is subjected to flux cleaning by conventional flux cleaning techniques.

[0029] Next, an etching mask is selectively applied to the top of a die attach pad portion of the first metal strip 18 (Figure 1H). In the present embodiment, the etching mask is a photo-imageable etch resist such as a photo-imageable epoxy that is spin coated on the leadframe strip and selectively exposed to light using a photo-tool for masking. The exposed portions are then removed and the leadframe strip 20 is subjected to a chemical etch (Figure 1I). In the present embodiment, the chemical etch is an alkaline etch that selectively etches away the metal to define the power ring 24, the contact pads 26, as well as the die attach pad 30 and the ground ring 22 under the etching mask. The etching mask is then stripped from the die attach pad 30 and the ground ring 22 (Figure 1J).

[0030] Referring to Figure 1K, a singulated semiconductor die 32 is mounted to the die attach pad 30, using known techniques. In the present embodiment, solder paste is dispensed on the die attach pad 30 and the semiconductor die 32 is attached by a solder reflow technique. The semiconductor die 32 is coated with a suitable surface for soldering, such as titanium (Ti), tungsten (W) or gold (Au) for mounting by solder reflow. In an alternative embodiment, the die is attached using a silver-filled epoxy, as will be understood by those skilled in the art.

[0031] Wires 34 are then bonded between the semiconductor die 32 and the ground ring 22, between the semiconductor die 32 and the power ring 24, and between the semiconductor die 32 and the contact pads 26. The wires 34 are made of a suitable wire-bonding material such as gold (Au), copper (Cu), aluminum (Al) or doped aluminum. The preplated silver (Ag), nickel/gold (NiAu) or nickel/palladium (Ni/Pd) facilitates wire bonding to the ground ring 22, the power ring 24 and the contact pads 26. The leadframe 20 is then molded using a modified mold with the bottom cavity being a flat plate, and subsequently cured, as discussed in applicant's United States patent no. 6,299,200, the contents of which are incorporated herein by reference.

[0032] Next, the tin or solder plating is stripped from the bottom surface of the leadframe 20 (the lower surface of the second metal strip 28) (Figure 1L). The metal at the bottom surface of the leadframe strip 20 is then removed. In the present embodiment, the metal is removed by subjecting the leadframe 20 to an alkaline etch (Figure 1M).

[0033] A solder reflow technique is used to separate the tin or solder plating on the bottom surface of the mold compound, leaving tin or solder plating on the lower surfaces of the die

attach pad 30, the power ring 24 and the contact pads 26 (Figure 1N).

[0034] Singulation of the individual units from the full leadframe array strip is then performed either by saw singulation or die punching resulting in the final configuration shown in Figure 1O.

[0035] Reference is now made to Figures 2A – 2O which show a process for manufacturing a Leadless Plastic Chip Carrier (LPCC), according to a second embodiment of the invention. Referring to Figure 2A, an elevation view is provided of a first metal strip 18 that forms a part of the raw material of the leadframe strip (indicated generally by the numeral 20 in Figure 2F).

[0036] Referring to Figure 2B, an elevation view is provided of a second metal strip 28 that forms a second part of the raw material of the leadframe strip 20. The second metal strip 28 is similar to the first metal strip 18 and therefore need not be further described herein. Similar to the first embodiment, the second copper strip 28 of the present embodiment is plated with tin (Sn) or solder on both upper and lower surfaces thereof (Figure 2C). The coating serves to enhance lamination and etching resist.

[0037] Next, a solder flux is applied to the top, tin-plated surface of the second metal strip 28 (Figure 2D). Alternatively, flux is applied to the bottom surface of the first metal strip 18.

[0038] The first and second metal strips 18, 28, respectively, are then laminated together by hot rolling with the solder flux disposed therebetween (Figures 2E and 2F). The hot rolling causes the plated tin or solder to reflow and wet the bottom surface of the first metal strip 18, thereby solder bonding the first metal strip 18 to the second metal strip 28. After hot rolling, the leadframe strip 20 is subjected to flux cleaning by conventional flux cleaning techniques.

[0039] Next, the first metal strip 18 is selectively plated with a preplating metal such as silver (Ag), nickel/gold (Ni/Au) or nickel/palladium (Ni/Pd) (Figure 2G). The preplating metal is selectively plated in a pattern of a ground ring pad 22, a power ring 24, and contact or I/O pads 26.

[0040] The process steps shown in Figures 2H to 2O are similar to the process steps shown in Figures 1H to 1O described herein above, and therefore need not be further described herein.

[0041] Reference is now made to Figure 3 which shows a bottom view of the LPCC of Figure 1O, including the underside of the die attach pad 30, the power ring 24 and the contact or I/O pads 26.

[0042] Reference is now made to Figures 4A to 4M to describe a process for manufacturing

a LPCC according to a third embodiment of the present invention. Referring first to Figure 4A, an elevation view is provided of a first metal strip 18 that forms part of the raw material of the leadframe strip (indicated generally by the numeral 20 in Figure 4G). In the present embodiment, the metal strip 18 is a copper strip.

[0043] The metal strip 18 is selectively plated with a preplating metal using plating resist to define the plating areas. As previously described, the preplating metal is preferably silver (Ag), nickel and gold (Ni/Au) or nickel and palladium (Ni/Pd) (Figure 4B). The preplating metal is selectively plated in a pattern of a power ring 24, and contact or I/O pads 26. Note that no ground ring is provided in the present embodiment.

[0044] Referring to Figure 4C, an elevation view is provided of a second metal strip 28 that forms a second part of the raw material of the leadframe strip 20. In the present embodiment, the second metal strip 28 is also a copper strip. The second metal strip 28 is similar to the first metal strip 18 and therefore need not be further described herein.

[0045] The second metal strip 28 is plated with tin (Sn) or solder on both upper and lower surfaces thereof (Figure 4D). The coating serves to enhance lamination and etching resist.

[0046] Next, a solder flux is applied to the top, tin-plated surface of the second metal strip 28 (Figure 4E). In an alternative embodiment, flux is applied to the bottom surface of the first metal strip 18.

[0047] The first and second metal strips 18, 28, respectively, are then laminated together by hot rolling with the solder flux disposed therebetween (Figures 4F and 4G). The hot rolling causes the plated tin or solder to reflow and wet the bottom surface of the first metal strip 18, thereby solder bonding the first metal strip 18 to the second metal strip 28. After hot rolling, the leadframe strip 20 is subjected to flux cleaning by conventional flux cleaning techniques.

[0048] Next, the leadframe strip 20 is subjected to a chemical etch (Figure 4H). In the present embodiment, the chemical etch is an alkaline etch that selectively etches away the metal to define the power ring 24, and the contact pads 26. Unlike the first described embodiment, no die attach pad is formed.

[0049] Referring to Figure 4I, a singulated semiconductor die 32 is mounted to the plated second metal strip 28, in the center of the power ring 24 using known die attach techniques. In the present embodiment, solder paste is dispensed on the plated second metal strip 28 and the semiconductor die 32 is attached by a solder reflow technique. The semiconductor die 32 is

coated with a suitable surface for soldering, such as titanium (Ti), tungsten (W) or gold (Au) for mounting by solder reflow. In an alternative embodiment, the die is attached using a silver-filled epoxy, as will be understood by those skilled in the art.

[0050] Wires 34 are then bonded between the semiconductor die 32 and the power ring 24, and between the semiconductor die 32 and the contact pads 26. The wires 34 are a suitable wire-bonding material such as gold (Au), copper (Cu), aluminum (Al) or doped aluminum. The preplated silver (Ag), nickel/gold (NiAu) or nickel/palladium (Ni/Pd) facilitates wire bonding to the power ring 24 and the contact pads 26. The leadframe 20 is then molded using a modified mold with the bottom cavity being a flat plate, and subsequently cured.

[0051] Next, the tin or solder plating is stripped from the bottom surface of the leadframe 20 (the lower surface of the second metal strip 28) (Figure 4J). The metal at the bottom surface of the leadframe strip 20 is then removed. In the present embodiment, the metal is removed by subjecting the leadframe 20 to an alkaline etch (Figure 4K).

[0052] A solder reflow technique is used to separate the tin or solder plating on the bottom surface of the mold compound, leaving tin or solder plating on the lower surfaces of the semiconductor die 32, the power ring 24 and the contact pads 26 (Figure 4L).

[0053] Singulation of the individual units from the full leadframe array strip is then performed either by saw singulation or die punching resulting in the final configuration shown in Figure 4M.

[0054] Reference is now made to Figures 5A – 5M which show a process for manufacturing a Leadless Plastic Chip Carrier (LPCC), according to a fourth embodiment of the present invention. Referring to Figure 5A, an elevation view is provided of a first metal strip 18 that forms a part of the raw material of the leadframe (strip indicated generally by the numeral 20 in Figure 5G).

[0055] Referring to Figure 5B, an elevation view is provided of a second metal strip 28 that forms a second part of the raw material of the leadframe strip 20. The second metal strip 28 is similar to the first metal strip 18 and need not be further described herein. Similar to the first embodiment, the second copper strip 28 of the present embodiment is plated with tin (Sn) or solder on both upper and lower surfaces thereof (Figure 5C). The coating serves to enhance lamination and etching resist.

[0056] Next, a solder flux is applied to the top, tin-plated surface of the second metal strip 28 (Figure 5D). Alternatively, flux is applied to the bottom surface of the first metal strip 18.

[0057] The first and second metal strips 18, 28, respectively, are then laminated together by hot rolling with the solder flux disposed therebetween (Figures 5E and 5F). The hot rolling causes the plated tin or solder to reflow and wet the bottom surface of the first metal strip 18, thereby solder bonding the first metal strip 18 to the second metal strip 28. After hot rolling, the leadframe strip 20 is subjected to flux cleaning by conventional flux cleaning techniques.

[0058] Next, the first metal strip 18 is selectively plated with a preplating metal such as silver (Ag), nickel/gold (Ni/Au) or nickel/palladium (Ni/Pd) (Figure 5G). The preplating metal is selectively plated in a pattern of a power ring 24, and contact or I/O pads 26.

[0059] The process steps shown in Figures 5H to 5M are similar to the process steps shown in Figures 4H to 4M described herein above, and therefore need not be further described herein.

[0060] Specific embodiments of the present invention have been shown and described herein. However, modifications and variations to these embodiments are possible. For example, the leadframe strip is not limited to copper and can be any suitable metal such as an iron-based alloy. Also, in the embodiments of Figures 1 and 2, the metal at the bottom surface of the leadframe strip is removed by subjecting the leadframe to an alkaline etch. The bottom strip can be removed in other ways. For example, the bottom strip can be removed by heating to detach the bottom strip. Also, the step of flux cleaning is not necessary. Those skilled in the art may conceive of many other modifications and variations, all of which are believed to be within the scope and sphere of the present invention.